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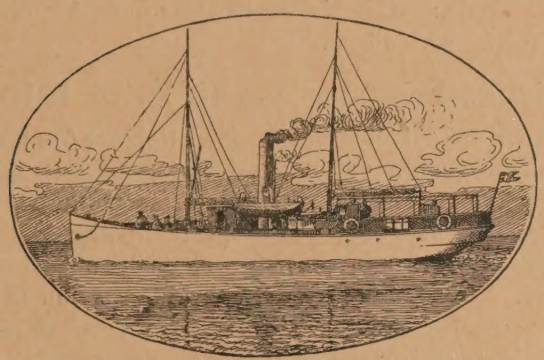
Report

of

The Danish Biological Station

to

The Board of Agriculture.



XXVII.

1920.

By

C. G. Joh. Petersen,
Ph. D., L. L. D.
Director.

Copenhagen.
In Commission by G. E. C. Gad.
Centraltrykkeriet (C. Ferslew).
1921.

C. G. Joh. Petersen: Om de skalbærende Molluskers Udbredningsforhold i de danske Have indenfor Skagen 1888. 8°. 162 pg. 2 Kort.

Det videnskabelige Udbytte af Kanonbaaden »Hauch«s Togter i de danske Have indenfor Skagen. 1893. 4°. 464 pg. Atlas i folio.

Indhold: Echinodermata (Petersen), Diatomeer (Cleve), Undersøgelse af nogle Bundprøver (Rørdam), Mollusca (Petersen), Cephalopoda (Posselt), Crustacea malacostraca (Meinert), Hydrografi (Rørdam), Polyzoa (Levinsen), Ascidiæ simplices (Traustedt), Annulata, Hydroidæ, Anthozoa, Porifera (Levinsen), Nogle alm. Resultater (General Results, Engl.) (Petersen).

C. F. Drechsel: Oversigt over vore Saltvandsfiskerier med Kort og Planer. 1890. 4°, 100 pg. Med et Tillæg: »Om Naturforholdene indenfor Skagen« af *C. G. Joh. Petersen.* Med Kort. 4°. 46 pg.

Fiskeri-Beretning for $18^{88}/_{89}$ til 1916.

Beretninger fra den danske biologiske Station findes paa dansk publiceret i de tilsvarende Fiskeri-Beretninger, til Beretning XXI med Tillæg. Senere udgives de som selvstændige Publicationer paa Dansk og paa Engelsk.

The Reports from The Danish Biological Station are also published in Danish in the corresponding Fiskeri-Beretning, until Report XXI with Appendix. Later on they are specially published in Danish and in English, but not in the Fiskeri-Beretning.

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II. Om vore Kutlingers *(Gobius)* Æg og Ynglemaade. (1891—92.) 9 pg. Med 2 Tavler.
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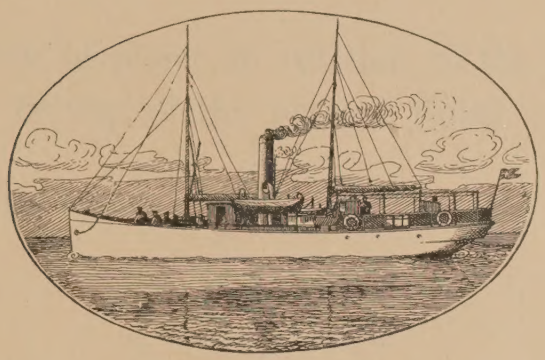

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On the stock of plaice in relation to the intensive fishing of the present times in the Beltsea and other waters

by

C. G. Joh. Petersen.

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Introduction.

During the past 21 years I have had the opportunity so to speak, of following with my own eyes, the fate of the stock of plaice in the Belts, while an intensive fishery with seine and motorboats developed there; earlier gill-nets were used for fishing here at single places where the current permits such fishing. At the beginning (1899) I did not think that what has happened during these years would happen, or else I should have planned the investigations otherwise; most of what happened has been a string of surprises to me. The war, with mine-zones and mine-dangers, has for several years waylaid my planned investigations; after the war I found another stock of plaice than the old one, and in the following pages I will try to picture what has happened to this stock during these 21 years.

The plaice now fished are young, bigger and better fish than formerly, but there are fewer plaice per ha. now than before, although the yearly yield in kilogrammes of fishing is larger. We here meet a phenomenon like the over-fishing phenomena at other places, but differing, amongst other things, from these in that the plaice on an average have grown bigger than they were. The plaice we got formerly we did not care to eat on board when we caught them; now we regard them as delicacies. In earlier times a score of plaice cost 1 Kr. in these waters, now about 20 Kr. or more, and this change is far from only being due to the changed state of the money market. The discernible influence which the fishing has had on the stock of plaice in these small waters is of great interest for the comprehension of the conditions in other, bigger waters, and mainly for the judgement of how the stock of plaice in the ocean ought to be treated, in order to get the largest production of good plaice per annum. In this relation we must not think of the plaice only, but also of the food available.

Magister *H. Blegvad*, the assistant of the station, has contributed very much to the completing of this work, as he has made the measurements and the determinations of the age of the plaice by means of the otoliths. We both therefore guarantee the correctness of these definitions.

Since The Biological Station in 1889 gave rise to the introduction of the seine-fishing for plaice in the Great-Belt, a considerable fishery with different seine-apparatus has developed in the Beltsea, and the stock of plaice has, during the past 21 years, undergone a considerable change for the better; unfortunately the war has hampered me in the following of this matter without interruption through these years; but in spite of this I am able to give a rather detailed view of what has happened.

In order to follow the course of the plaice-fishery in the belts, both concerning weight yield and money value, one may best use The Fiskeri-Beretnings statistics through the years. (See page 14).

The statistics certainly give on broad lines the development of the plaice-fishing in these waters; slight inaccuracies and mistakes may be ignored.

The seine with otterboards has certainly been used some years before 1912; it will be seen how this seine has increased in number from 1912 to 1919, while the plaice-seine has decreased somewhat in number; the latter has been used before 1902, even if in small numbers. In 1899 I gave cause to their introduction in the Great-Belt by publishing, that a lot of plaice was found S. of Sprogø in 10 fathoms of water; in the Great-Belt no plaice-seines or seines with otterboards were used before 1899, but only gill-nets. The number of nets has during the years 1901—1919 been fairly constant. For the year 1903 a wrong number has evidently entered the statistics.

The weight per head or by the score of the plaice is not as a rule stated in the statistics, but *A. C. Johansen* 1912 page 114, however, has been able to state from this, that the plaice in the Great-Belt in the nineties with slight variation weighed 5 kg per score, and from cutterlogs from the Great-Belt and from the W. part of the Baltic in 1899—1906 on an average somewhat less than 5 kg per score; more than 40.000 score have been calculated in this last statement, wherefore it may be considered representative.*)

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*) According to *Johansens* information 1912 page 115 it will be seen, that especially towards the South in The Lesser Bælt plaice were found before 1900 weighing up to 7,5 kg per score, thus somewhat heavier than usual; this fact has been known to me for several years, even in the waters between the islands South of Faaborg, where certain very definite deep basins are to be found; these basins are presumably only in a slight degree supplied by the access of young, and thus have not suffered from overpopulation. These deep holes are especially well fitted for the old-fashioned fishing with gill-nets, as the current here is very weak, and it may be that the net-fishing has helped to hinder over-population in these localities quite some time before the introduction of the seines.

Fiskeri-Beretning for 1919, page 9, mentions that plaice of an extraordinary size, 8 kg per score, are fished near the island of *Møen* in the Baltic and in abundance; earlier, about 1903, according to *A. C. Johansen* 1905 page 34, they weighed 3—5 kg and were all of them mature before reaching the length of 25 cm. I very distinctly remember from the nineties, these meagre, small plaice which hardly anybody wanted to eat; now in 1920 several big boats from the northern part of Seeland are fishing near Møen, because it pays better than the fishing in Kattegat, — an unmistakable proof that the plaice near Møen have grown better than they used to be.

According to kind information from the Director of the fisheries the control in 1912 appears to be surprised at the appearence of »big spawn-filled plaice« in the belt of Samsø, and in the Fiskeri-Beretning for 1912 page 6 it is mentioned that, as far as the Beltsea is concerned, »plaice of a considerably better quality than the nearest preceding years« have appeared, weighing up to 10 kg per score.

It must be remembered, that in these reports of weights per score we reckon with the plaice taken ashore by the fishermen only, and not with the great many inferior individual fish under 26 cm in length; these appeared previously in great number. Now fewer undersized individuals are found on the fishing grounds, where the fishing mainly takes place, except near Møen in the Baltic, where a great deal of undersized fish is caught and thrown overboard.

The statistics thus show that since about 1900, after the introduction of the seine, the fishery has increased to a very considerable intensity, and this is seen in the fact that more than one-thousand tons are now fished per annum, against about 500 tons before 1900. The price per kg of plaice has during this period increased three-four times, which is due to the better quality and size of the plaice as well as to several conditions following the war. The pecuniary yield before the year 1900 was something more than 100.000 Kr. per annum; in the last nine years it has changed from between one half up to three millions of Kr. The three years 1912, 1913 and 1919 with their enormous yield in kg, over and under three thousand tons, are remarkable; a change like this from good years to less good years may surely be expected in the fishery. It might perhaps be thought that the decrease i 1914—1918 was due to the war, but the fishing during the war, as a rule, has been nearly as intensive as before and after.

At present a greater weight of plaice is caught per annum than twenty years ago, and the plaice is bigger, about 10 kg per score against 5 kg previously. While a plaice-seine-cutter in 1899 was able to catch up to 40 score per haul South of Sprogø, now only about 6—10 score af plaice are caught per diem with the modern seine with otterboards, these seines however catch very well; and while we in 1899 with our short lines (300 fathoms) on the plaice-seines on an average got 2—3 hundreds of plaice per haul, we now get one, two or even none whatever. In spite of the fair annual yield, only very few plaice are fished per diem and per hectare in the Belt; they do not lie so closely together on the bottom as previously; the fishermen are well aware of this fact. But why are the plaice now on an average bigger than before, and how is it possible, that the annual yield can be so considerable when only such a small amount of plaice can be fished per cutter per day?

In order to understand these apparently strange conditions we must investigate what has happened to the stock of plaice during these years, and what its composition has been at the different times.

Table 1 page 18 shows the plaice as they were fished in the year 1900 on the fishing-grounds S. of Sprogø in the Great-Belt, 22 m depth. Table 2 shows a great deal of plaice S. of Slipshavn, also in the Great-Belt from 1903, which was in the old days, before the fishing really developed; on both tables a great deal of undersized individuals are to be found, i. e., plaice less than 26 cm length; big plaice somewhat more than 40 cm were also found even if in small numbers. There was a great majority of males (♂).

Table 3 shows some plaice, partly fished and partly bought, from the Great-Belt 1920; it is at present impossible to catch approximately as much plaice as we fished in 1903 without a considerable loss of time. Fishermen and fish-dealers are able to show a great deal of plaice, and we have seen them, and I think that the plaice measured on table 3 are true representatives of the plaice fished and put on the market. It will be seen that there are now hardly any undersized fish, and the females (♀) are now in majority over the males. The plaice are now, on an average, of a greater length and of more weight than before, but the biggest of them are no larger than the biggest plaice were earlier.

In the year 1900 no determination of age was made; then *Reibisch's* otolith-method was only just advancing, and therefore, I regret to say that I am not able to state how old the plaice from 1900 and 1903 were; but in 1909 *A. C. Johansen* (see table 4) has examined some plaice of similar size from these waters, and they are as a rule 5—7 years old, some of them even more than 14—18 years old. It will further be seen, from table 4, that the males already in 1909 on these grounds are fewer in number than the females. The fishing has taken away many of these certainly very old males, and most probably has removed many old females too; we must suppose that the plaice shown on tables 1 and 2 have been still older than those on table 4; further, a great deal of undersized fish are to be found on these lists, about 4—7 years old.

The tables 5—8, all of them from September 1920, show what are the conditions in regard to age at present in the Great-Belt; plaice older than 3—4 years are now a rarity as compared with what they used to be, and even the 3—4 yearlings are now on an average bigger than the old plaice were in earlier times.

From the Western Baltic *Reibisch's* investigations as regards the age of the plaice are to hand. Some of these are shown on the tables 14 and 15. Our measurements and determinations of ages from 1920 are, on these tables, printed with heavy type; these figures are seen to be almost beyond his figures, because the plaice now, when younger, are bigger, i. e. they are more quick-growing.

Table 9 and 10 are comprised partly from *Reibisch's* and partly from our own investigations and show very clearly the difference of the sizes of the plaice from 1908—9 and of the plaice from 1920.

On table 16, made up in the same way as the tables 14—15, the figures from

the true Baltic, near Møen, on the other hand, are seen to be somewhat alike, but still with a distinct tendency towards younger and bigger, and more quick-growing fish.

The tables 11, 12 and 13, like tables 9 and 10, show in a very clear way the sizes of the plaice before and in the year 1920 in the true Baltic, E. of Møen; on these five tables it is also shown how the number of the males has decreased in relation to that of the females, so that the females now predominate. The intensive fishing has thus in the Western Baltic developed similar changes in the stock of plaice to that of the Great-Belt, and is evidently doing it in the true Baltic too, but the development is not so advanced here as in the Western Baltic, and in this place not so advanced as in the Great Belt. The plaice from the Baltic (Bagenkop and Møen) which have been investigated, are purchased plaice, but the fishermen have informed us that the purchased plaice are exceedingly representative for the stock in the Western Baltic, but perhaps somewhat more undersized individuals are to be found near Møen than those given on table 13.

These analyses of the stock of plaice thus show, that the oldest, biggest plaice are fished away from the Beltsea, but the growth of the 3—4 yearlings is so quick, that the average size of the plaice now fished on the real fishing grounds in deeper water is more considerable than before.*) The explanation of this evidently is as follows: the older numerous stock of old slow growing fish consumed the available supply of food without considerable increase of body per annum; these being fished away much more room was made for the young plaice which now grow up quickly and are fished away more quickly.

But how is it possible that the intensive fishing in the Beltsea is able to make the plaice bigger? As a rule they grow smaller in average-size by intensive fishing, because they do not now have sufficient time in which to grow big. Such was the case in Kattegat as far as we know, in the North-sea before the war, and near Iceland and in the Barents sea. It must be admitted that the old and big plaice, which sometimes were to be found in the Beltsea weighing 2—$2^1/_2$—3, even 4 kg. each, have grown scarce now; so old, perhaps 20 years or more, they do not grow any more; but these very old plaice have always been so rare, that they played an unimportant part in the average size of the plaice fished.

The increased average-size of the plaice fished in the Beltsea needs a special explanation, and this is to hand, when one compares the distance the young plaice (1—2—3 years old) must travel from the coast to the deep waters in the different seas with which we are dealing here. We know how difficult it is for the young plaice to find its way into the interior of the Limfjord, where there is to be found a very good feeding place with ample supply of food in

*) In shallow waters, near the coasts and for instance between Langeland and Fyn near Lundeborg, one can now, as well as earlier, fish many young (1—2—3—years old) and small plaice; this is proved by measurements. These young have always been present in these waters, even if in varying numbers; in these places the individuals of group I—II appear to be bigger than they were before, and the migration to deeper waters probably takes place earlier than before; now it is mainly the III group which emigrates, and if in a somewhat lesser degree the group II. I will not go into details of this matter here.

certain years; they often stay in Nissum Broads till they are about 4—5 years old without growing more than a trifle per annum; the whole of the artifical transplanting of young plaice is based upon this knowledge. We see, near Esbjerg, how the young plaice stay near the coast for a long time, 4—7 years, without growing big and without maturing. *A. C. Johansen*, 1920, has lately shown that the protection given by the war has made the plaice bigger at Esbjerg, but also more slow-growing than before, in such a way that they now are 4—7 years of age without being mature and without leaving for the deeper waters. In the Kattegat the plaice must travel from the coasts of Jutland to the E. part of the Kattegat or S, of Anholt in order to grow big and mature, and this often takes 4—5 years; but in the Beltsea where there is room and food enough for them, they grow big and mature in the course of 3—4 years ($^1/_2$ kg). In these small waters the plaice need not at all travel so long a distance in order to reach the real growing-places, as is the case in the Kattegat and the North Sea; they very often only need to move some few miles in order to reach these places; and further the bottom-conditions, being stone-bottom and plant-growths, are such that the plaice for considerable areas, where they live as young, 0—1—2 years old, are only slightly exposed to the persecution of the fishermen with their seines. These quite young plaice are therefore not much fished for in the Beltsea where the water is shallow, and soon they arrive at their real growing places; this is the cause of the quick renewal of the stock on these grounds, a renewal which evidently takes place in a much quicker way than in the greater waters, and which proportionately gives a considerable annual yield, as the food on the bottom is all used and in such a profitable way, that it is not left too long as food for harmful animals and other kinds of fish.

On the even sea-bottom of the Beltsea, to which the plaice belong, are found only two animal-communities, the *Macoma baltica* community nearest to the coast, and in deeper water the *Abra alba* community; it is in the latter locality that we find the growing places of the plaice; the thin-shelled *Abra alba* is their favourite food in these waters; our valuation investigations have often showed that we need only find the richest number of *Abra*, to find the plaice; the number of *Abra* varies very much in the different years, but they are often found on the deep clay-plains, and more or less in patches; it is beyond any doubt that on the ocurrence of this mussel and the annelids *(Nephthys)* accompanying it, depends the growth of the plaice to the greatest extent in these waters and thus also the fate of the plaice-fishery. Unfortunately the plaice has in the dab a strong competitor for this *Abra*-food; the quite small dabs which, in contrast to the young plaice, live in the deep waters, eat the small *Abra*-brood in large quantities, while the grown-up dabs consume the grown-up *Abra;* if the number of dabs could be kept low by means of the fishing, this would surely be profitable for the growth of the stock of plaice, and perhaps it is not impossible to do something in this respect.

The quick renewal of the stock on the growing places in the Beltsea, on account of the short journeyings in connection with a considerable, voluntary and involuntary, lenience towards the quite young plaice, are evidently special conditions which are more advantageous for these waters than for others, hence the bigger average size of the plaice on account of the intensive fishery and the great annual yield

in weight; similar results might in bigger waters; perhaps be attained only by transplanting of young plaice, similar to what happens in certain parts of the Limfjord; for in the Limfjord the distances which the plaice have to travel in order to reach the growing places is many times longer than is the case in the Beltsea. In the Beltsea, such things as are only attained in other places through artificial transplanting, so to speak, takes place in a natural way.

Experiments with the transplanting of young plaice to the Doggerbank have during the previous years been made in a way which I proposed; the experiments showed a very quick growth on the Doggerbank. I just want to mention that these experiments for many reasons are difficult to accomplish with a mere practical object in view; I mention them in this place as they throw light upon the biological conditions of the stock of plaice both in the North Sea and in the Beltsea.

It appears to have been in 1912 that for the first time it was noticed that a great number of big plaice suddenly appeared in the Great Belt, the appearance of which was not then understood; as far as is known, the fishermen presume that it is an immigration from the North of the so-called northern Kattegat-race with the high number of fin-rays, about 54 rays in the anal fin, but our recountings of this year of plaice from the Great Belt, show that a low number of rays, about 50, is to be found on big ones as well as small ones near the coast, and that the older ones, (3—4 years old) must be considered as originating from the young near the coasts; during one year, from about the third to about the fourth year, they grow from small to big plaice, which shows that a quick growth of the big plaice can take place in the Belts.

Whence this fry, near the coast, comes I shall leave unsaid; various homesteads are possible.

The original, dense, old, little-producing stock has thus fortunately been fished away; a new quick growing stock, fewer in number per hectare, has appeared; if the fishing was not carried on in such an intensive way as is the case, the old conditions would return once more, but just the intense fishing prevents this, and at the same time increases the annual yield. It is like a lawn which is cut many times per year, in lieu of once every second year; the latter method produces old, bad grass only, the former gives much more and better grass, but calls for much more work.

What has earlier been written on the protection of the stock of plaice in the Beltsea etc. is now only of historical interest, for which reason I do not further treat it here. It is seen that the minimum-size 26 cm. for the plaice ought not to be fixed lower in these waters, and hardly in the Eastern parts of the Baltic, when the old dense stock has been fished away; in this place an intensive fishing is likely to improve the growing conditions of the plaice. —

When 4—5 times as many kilogrammes of plaice have been fished in 1919 in our southern waters as before 1899, at a value which is twenty times as big as then, ought we not to be content? I, at least am proud to have contributed to a considerable degree to the extension of the seine fishing in these waters since 1899. But if these waters are able to yield even more kilogrammes of good plaice per annum than is the case at present, we must not be quite content. The weight-yield

in 1919 of the plaice-fishery of Denmark in all our southern waters put together, Øresund excepted, were, according to the statistics, very nearly equal to the plaice-fishing of the Kattegat, our ancient, classic fishing place; this is even more than I have ever thought possible, although these two areas of water are nearly of the same size; in comparison with the Thisted Broads these waters ought to give much more; but such a comparison is for various reasons not quite just.

I dare not yet speak with certainty about the available stock of food on the sea-bottom in our southern waters; the war has prevented the proper investigation of this matter, but one thing I think must be recommended, a prohibition against landing of plaice in the spawning season; for then the plaice are very meagre, the females filled with eggs and only of a slight sales-value; this is however improved after the breeding-time. By means of such a protection during the winter, it would further be gained, that more plaice would be able to breed every year, and a result of this would most likely be a greater number of young plaice near the coasts; whether they would be able to grow into mature fish depends upon the available amount of food, and this is likely to change with the years. If a sufficient amount of food was not at hand, the plaice would grow more slowly and thus be fished as smaller fish, although, not undersized, and on account of this be of a lesser value; if sufficient food was at hand, a greater number than is now the case would grow up. The amount of plaice fry seems to vary considerably in the different years as regards number in these waters. At this moment it is impossible to say whether it would be desirable to increase the number of the growing plaice or not; the future may inform us as to this. But at all events it seems advisable to use the already grown up plaice in their best season, when they are most valuable. Unfortunately such a close time must be rather considerable, several months, if it is to be of any use.

In the future the fate of the stock of plaice in the Beltsea must be watched very carefully; there is a possibility that the fishing will grow more intensive than is the case at present, when fishing apparatus and kerosene are cheaper, and then possibly more fish than the stock is able to produce will be fished away; this will be seen in the fact that the total catch per annum decreases; only then can it be known that the fishing is too intense; for no one knows how many kilogrammes these waters are able to produce per annum, at least not yet. —

It is characteristic to see, that we in a single haul with a plaice-seine, are now getting only few plaice or none whatever in these waters; the same thing is however also seen in Thisted Broads, when it is planted so full of plaice as can be expected to be able to grow big in the course of 6—9 months. The plaice must be very well spread in order to grow well; 40 to 60 per hectare has proved to be sufficient in the best parts of the Limfjord with its ample fish-food; as a rule this is certainly more ample than the fish-food of the Beltsea. —

The conditions of the Beltsea have shown that the stock of plaice has a considerable power of accommodation in the face of the influence of the fishing. If the fishing is not intensive, the stock grows dense, but the individuals are hampered in their growth by this; if the fishing is still more intensive the stock is thinned out, but the individuals grow more quickly, and the annual catch is

greater. This thinning out of the stock may with profit be carried on only to a certain extent; for if it is carried on too far the fishery does not pay; such a limit has almost been reached already, especially, amongst other things, because the kerosene is so expensive; it is to be hoped that the stock of plaice will be able to regulate itself according to the varied intensity of the fishing at the different times, in other words, according to the prices of kerosene, fishing nets etc., and last, but not least, according to the prices paid for the plaice itself. These as mentioned above, will be the problems of the future to follow more carefully; but after what has already been illustrated, I believe strongly in the power of accommodation of the plaice in the Beltsea, provided that the plaice are not fished while too small and of too little value. —

In »Dansk Fiskeritidende« dated September the 10th 1912, number 37, I wrote a short notice, then showing my fears of the intensity of the seine-fishing for plaice in the Beltsea; I assumed that this must be limited by means of legal restrictions; I did not then know the consequences of the seine-fishing, namely a quicker growth of the plaice and of the stock as a whole in these waters; I only saw that less was caught per diem than formerly, and the fishermen were aware of the same fact. The plaice has since proved to be able to pull through; but I am certainly going to be very careful and not state what is going to happen in the future. —

Since I wrote in 1893 for the first time on the Danish plaice fishing, we have seen that an intensive fishing in a water is able to fish away the big old plaice, in such a way that the average size decreases, as is the case in the Kattegat, the North Sea, by Iceland etc., i. e. the old stock is fished away and is not renewed quickly enough; in these places a protection, such as was given by the world-war, will be able to develop an increase in the average size, simultaneously with an increase in the age of the plaice fished; but this will be done at the cost of the speed of the growth. (Esbjerg).

We have further seen how an intensive fishing in the Beltsea certainly fished away the older stock, but that a younger stock, more weighty per score, rose in this place and spread in such a number that the annual yield in kilogrammes also became larger than formerly. An intensive fishing can thus be of harm to some waters and of benefit to others. Intensive fishing or protection is not always of the same effect in the different waters. —

A strong protection of the plaice in the whole of the Limfjord would thus be of no value, it would only give an overpopulation in Nissum Broads and be of no help to the Thisted Broads; the plaice are too few here to protect if no transplanting is done; in other words the protection of the young in a water may bring about slow growth (over-population) if the young ones do not spread in the water and use the available amount of food. How a water such as the North Sea should therefore be treated is a large question; the consequences of the protection in this water will be very much dependent upon the ability of the young to spread over the sparsely populated areas.

The whole problem as regards the right treatment of the stock of plaice in a certain water is, of course, as in other fishery, the acquisition of a suitable num-

ber of young fish per hectare, in order that they may use all the food which is to be found on the sea-bottom, and then protect them till they reach a proper size. The situation as to other animals, which compete with the plaice for the food, of course plays a great part. I shall not here go into details regarding this aspect of the matter.

It appears to be very good in all waters that the original dense stock of old, slow-growing plaice is fished away, giving room for a less dense stock of young fish, which grow more quickly because they are fewer in number per hectare than they used to be; but in the latter case, an essential point must be considered, namely the power of spreading of the young fish.

At Esbjerg, it seems from *A. C. Johansens* investigations 1919, page 24, that the protection due to the war has had the effect that the plaice have grown bigger, but also older and more slow-growing; instead of being 3—4 years old they are now 4—5—6—7 years old.

In the middle and northern parts of the Kattegat, and I daresay in all places, the old plaice have been fished away long ago, and the fishery now is mainly based upon the 3—4 years old plaice, but the conditions in the Kattegat are not set out so distinctly by modern investigations, that I am able to express myself with fair precision on the spreading conditions in this water; they are believed to be better than at Esbjerg, and a bigger minimum-size than the now ruling 26 cm. would surely be advantageous.

In the Beltsea we have, during the later years, seen the original stock being fished away, so that the fishery is now mainly based upon plaice of an age of 3—4 years, just as in the Kattegat; although some few of the old ones are left, but the 3—4 years old plaice are now growing so quickly, and are spreading in so rapid a way, that the average weight of the plaice fished has increased, in spite of the rather intensive fishery; the 3—4 year old plaice appear to have grown as big as the 5—10 years old plaice were in earlier times and the annual catch in kilogrammes is bigger than before.

In the Baltic by Møen such a change from older slow-growing plaice to younger, more quickly growing plaice appears to be taking place; this is partly seen by the fact that the oldest plaice, 9—14 years old, have grown very scarce, the most numerous now being the 4—7 year old plaice, and partly by the fact that the females are twice as numerous as the males; previously the opposite was the case.

As the point, as previously mentioned, is partly to get a suitable number of plaice spread out over the sea-bottom, in order to make them use the available food and grow quickly, and partly to have them fished before they grow too old, it is easily seen that a protection by the minimum-size will not be of the same effect in all the waters; in some places local over-population is found; here the protection would give still more over-population, and the growth would be slower; although, perhaps, more plaice are now able to arrive at a saleable size, even if more slowly, and the protection will thus be of importance here; this will of course be the case provided we want to get young ones to the water-area as a whole, and if the young are able and willing to spread without taking too many years in the process. The Beltsea appears to be in the best position in this respect; for

the spreading in this place evidently takes place quickly on account of the short distances which the young must cover; in this water the plaice are evidently using all the available food of the whole area, and are fished away quickly when they have reached a suitable age and size; here the conditions approach the cultivation of the Thisted Broads, where a suitable number of young plaice are transplanted in the Spring, 40—60 per hectare; they are nearly all caught again during the same year, having reached a proper size, and then fresh ones are transplanted the following Spring. In this water it is possible to effect an artificial regulation of the number per hectare, according to the amount of food in the different years; this is impossible in the big waters, but it is anyway useful to have it clearly thought out which method will be the most profitable in these waters; in the Kattegat and the North Sea we have got so far, that the fishing is mainly based upon only a couple of year-groups of the plaice.

It is now possible to value the amount of food for instance in the North Sea twice every year by means of a bottom-sampler, and determine the supply of food for the fish there; I dare predict that this will be done shortly, for the supply of food is the main condition for the growth of the fish; it is impossible to leave this out of consideration in the long run, such as has hitherto been done there.

It has now for quite a while been a subject for discussion that it is unfortunate that so many young plaice are destroyed in the North Sea, especially by the trawl-fishing; but it is only unfortunate provided that the food which they might have used in order to grow big, is not already used by other valuable fish, in such a way that these small plaice would not have any chances to grow big without spoiling other sorts of fish, for instance the haddock. It is thus a main question whether there is food enough for both, and whether the stock of plaice exposed to an intensive fishing can be maintained in the North Sea; if the latter, for instance, does not spread rapidly enough, it is impossible. As the plaice is of more value per kilogramme than the haddock, something special must be done for this fish; the protection must be tried; but a very difficult question to answer in advance is this »What will be the result of such a protection«?. Perhaps the power of spreading as a rule is greater than at Esbjerg; and without a protection the consequenses may apparently be fatal*).

In the first instance something must be known about this: Where is the food and how much is there of that food which could be used to feed the young plaice, and for what purpose is it used now? Is it used by another just as valuable fish, fit for food, or is it used to maintain a dense stock of star fish etc. which are only to be regarded as the harmful animals of the sea? In the latter instance here is where the damage is done; the significance of the young plaice as a fish of utility is only a possibility, but the food is a reality already; if the food is not used as much to the advantage as to the disadvantage of the production of the

*) It is strange that in this discussion the possibility is no longer debated, that the breeding plaice may grow so few in number, that there will not be sufficient fry; the fishing has really handled the big plaice roughly. The theory of growth, which I once put forth, appears to have triumphed over the propagation theory; but it is possible that too few breeding plaice exist, to which fact I called attention in 1893.

North Sea, this is the place where we must try to interfere. It is certainly the amount of food of the bottom animals which fix the limit for the production of the bottom fish in the North Sea and this is why it is a main consideration that the available food be used in the right way. An unlimited supply is not available as far as can be judged; but the best thing is to know as much as possible about this.

We must not regret that the original, dense stock of old slow-growing plaice has disappeared from the North Sea; it is no longer fit for the modern intensive fishing; the question about the plaice is now: how to get the best possible result out of the fish produced here; how much may be gained by means of the minimum-size and perhaps by means of transplanting, it is impossible to state beforehand; this must be tried out. Perhaps only certain parts of the old plaice-area can be kept up in the future as plaice-waters, but which are they? It is an advantage that the plaice are not allowed to grow old and slow-growing and in this respect the fishing is sufficiently intensive; to weigh the influence of this power on the growth of the stock of plaice in the best way is a problem for the future.

One can thus see further into the whole question as regards the protection of the stock of plaice than in 1893 when I first wrote on the Danish plaice-fishing; the conditions are now elucidated in a better way, but they are more complicated than I then thought. The question of the benefit of the protective measures is not only one of whether a plaice is able to grow, but also a question whether the stock of plaice will know how to spread, and a question whether suitable food is available, and last but not least, as to what degree of intensity the fishing is carried on at the different times.

All efforts to produce bigger plaice have a considerable advantage if successful, namely this: the bigger plaice are able to eat more and bigger and thus other food animals than the small plaice, and are therefore to a greater extent able to use the animals of the sea-bottom, a very essential qualification for the procuring of a quick-growing, much producing stock.

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Fiskeri-Beretningerne for the various years.

Remarks on the Statistics.

By the Beltwaters, in the statistics is understood the waters from about Samsø to North of Fyn as well as the Great and the Lesser Belts.

The Western Baltic is the water South of Fyn and Lolland to Gedser-Darsserort.

The Eastern Baltic is the water East of Seeland and Falster, not Øresund (the Sound).

The expression Beltsea used in this report means the Belt-waters and the Western Baltic.

The indication »Southern islands« in the statistics in the years 1902—1908, embraces the Beltsea and the Eastern Baltic as regards the fishing apparatus except the Southern part of the Eastern coast of Jylland (Jutland); for the year 1909 and later the number of apparatus is summed up for all the Beltsea and the Eastern Baltic, thus also for the Southern part of the coast of Jutland.

1902 the statistics for the first time include the number of the fishing-apparatus.

1912 the seine with otterboards is mentioned for the first time in the statistics, although it has been used some years previously.

The weight, value and price per kilogramme of the plaice are from 1885—1910 according to *A. C. Johansen* 1912 page 109, after that time according to Fiskeri-Beretningerne and apply to the Beltsea, and the Eastern Baltic. In the statistics this zone is alluded to as the Belt-waters as well as the Western and Eastern Baltic.

Statistics of the Plaice Fisheries in the Beltsea and the Eastern Baltic in the Years 1885—1919.

Anno	weight in tons	value in 1000 Kr	calculated price in Øre pr. kg	Number of apparatus		
				gill nets	plaice-seines	seines with otterboards
1885.	433	73	16,8			
1886.	404	80	19,7			
1887.	487	94	19,3			
1888.	622	109	17,5			
1889.	666	132	19,8			
1890.	708	145	20,5			
1891.	729	137	18,8			
1892.	617	119	19,2			
1893.	532	95	17,9			
1894.	546	104	19,0			
1895.	561	106	18,9			
1896.	673	114	17,0			
1897.	494	87	17,5			
1898.	635	127	20,0			
1899.	645	167	25,9			
1900.	703	169	24,1			
1901.	1.134*)	284*)				
1902.	787	196	24,9	14.903	121	
1903.	793	171	21,6	2.558	95	
1904.	1.172	231	19,7	19.337	0	
1905.	1.155	245	21,2	18.398	136	
1906.	1.163	308	26,5	20.132	15	
1907.	801	220	27,5	18.140	268	
1908.	1.070	291	27,2	15.519	233	
1909.	1.103	325	29,4	19.354	342	
1910.	1.553	468	30,5	16.551	397	
1911.	1.958	564	28,8	21.684	464	
1912.	3.522	1.015	28,8	22.004	528	549
1913.	2.941	917	31,2	28.182	481	883
1914.	1.643	573	34,9	24.007	481	840
1915.	1.152	545	47,3	22.973	460	918
1916.	1.115	704	63,1	20.864	314	949
1917.	1.234	882	71,5	21.338	311	965
1918.	1.387	1.192	86,0	21.475	267	1.025
1919.	3.135	2.792	89,1	21.024	314	1.391

*) plaices and flounders.

Remarks on the Tables.

Table 1—8 concerning the Great-Belt only.

— 1. Fished by ourselves mostly with a plaice-seine, partly with trawls with different meshes.

— 2. Fished by ourselves in 17 hauls with trawls with different meshes. Further 370 ♂ were fished and not measured, ♂ were thus three times the number of ♀.

— 3. Resumé of table 5—8 all from September 1920.

— 4. According to *A. C. Johansen.* Here omitted 25 individuals the age of which was not determined.

— 5. Fished by ourselves with Tog, a narrowmeshed seine apparatus with otterboards. They weighed about $8^1/_2$ kilogrammes per score.

— 6. Purchased from a fisherman using a seine with otterboards. They weighed about 8 kilogrammes per score.

— 7. Fished by ourselves in 4 hauls with a seine with otterboards, in all lasting 70 minutes. They weighed $5^1/_2$ kilogrammes per score. From this are omitted 3 individuals the age of which was not determinable.

— 8. Purchased from net-fishermen, who informed us that undersized fish, less than 26 cm. were very rare on this fishing-ground. They weighed 7 kg. per score, and we were informed that these fish were unusually small.

— 9. Resumé of table 14 and 15 *Reibisch* 1908—09 Western Baltic.

— 10. — — 14 — 15 my investigations 1920 Western Baltic.

— 11. Own investigations 1903. Fished by trawls. The Baltic East of Falster.

— 12. *Reibisch* 1908—09 Resumé of table 16 — — —

— 13. Own investigations — — 16 — — —

— 14—16. Embracing partly *Reibisch's* investigations 1908—09, partly our own from 1920; the heavy types give the measurements from 1920; it will be seen how the latter, in the tables 14—15, group themselves below and to the left of *Reibisch's*; this is because the plaice now, as younger, are bigger than formerly.

Something similar is seen on table 16 from the true Baltic, East of Falster, although a smaller degree.

The fish of table 14 from 1920 we have fished ourselves with different seine-apparatus, mainly narrow-meshed. The fish of table 15—16 are purchased from fishermen.

On 14 individuals, table 15, our own investigations 1920, purchased from fishermen, the determination of age was not quite certain, therefore they are placed between the individuals of the following age-class; the doubt has only been of two successive age-classes.

On table 16, own investigations 1920, purchased from fishermen, the same has been done in the case of 37 individuals; further omitted 6 quite uncertain determinations.

The black line below »26« cm on all the lists indicates the usual distinction between over-sized fish and undersized according to Danish law. The Fisheries Act of June the 2nd. 1917 fixes lower size-limits for the Baltic, both East and West, and for Øresund, in some places 22 and in other places 21 cm.

The great number of individuals in the tables from the previous years and the small number from 1920 prove how difficult it is to fish much plaice now in comparison with earlier times.

Measurements and Determinations of Age of Plaice from the Great Belt previous to and in 1920.

| Table 1. S. of Sprogø. 25./5.—28./5. 1920. Trawl and plaice seine. 22 m depth. | | Table 2 S. of Slipshavn. 22./8.—28./8. 1903 Eng. trawl. 13—17 m depth. | | Table 3 Plaice 1920 caught at Lillegrunden, S. of Sprogø, S. of Slipshavn and at Spodsbjerg. | | Table 4. At Tranekær (Langeland). 6.—10. April 1909 (A. C. Johansen). Plaice seine (9 m depth). | | |

The plain figures are from Reibisch's investigation, Aug. 1908—Octbr. 1909. — The heavy fig

cm	Western Baltic. Table 9. W. of Rügen. Aug. 1908–Oct. 1909 (Reibisch). ♂	♀	Table 10. Aug.–Septbr. 1920 (Own investig.) ♂	♀	True Baltic. Table 11. 12. May 1903 (Own investig.) ♂	♀	Table 12. E. of Falster (Møen). Aug. 1908–Oct. 1909 (Reibisch) ♂	♀	Table 13. 10. Septbr. 1920 (Own investig.) ♂	♀
5	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—
7	—	1	—	—	—	—	—	—	—	—
8	2	—	—	—	—	—	—	—	—	—
9	3	—	—	—	—	—	—	—	—	—
10	—	1	—	—	—	—	—	—	—	—
11	—	—	—	—	1	—	—	1	—	—
12	1	1	—	—	—	—	1	1	—	—
13	—	2	—	—	1	—	2	3	—	—
14	7	2	—	—	1	—	2	4	—	—
15	12	6	—	—	1	—	8	4	—	—
16	22	4	—	—	6	—	11	6	—	—
17	41	8	—	—	6	2	13	8	—	—
18	55	17	—	—	9	2	18	3	1	—
19	77	14	—	—	22	1	40	2	1	—
20	136	25	—	—	32	2	36	8	6	1
21	91	38	—	—	57	7	40	11	8	3
22	113	42	—	—	73	12	61	15	6	5
23	113	74	—	—	67	15	62	14	6	6
24	70	44	—	—	47	26	38	21	6	6
25	47	46	—	—	38	36	34	16	3	1
26	37	44	—	—	23	24	23	13	—	8
27	17	40	1	—	5	21	4	11	2	13
28	7	20	1	—	4	13	6	7	—	5
29	7	16	1	1	4	6	3	10	—	5
30	1	11	2	1	—	2	—	9	—	7
31	—	7	2	4	2	1	—	3	—	2
32	—	6	7	5	—	—	—	4	—	—
33	1	6	3	4	—	—	—	—	—	3
34	—	1	3	7	—	—	—	1	—	1
35	—	1	2	10	—	—	—	3	—	1
36	—	2	—	6	—	—	—	1	—	1
37	—	1	—	5	—	—	—	1	—	—
38	—	1	—	9	—	—	—	1	—	—
39	—	—	—	6	—	—	—	1	—	—
40	—	—	—	3	—	—	—	—	—	—
41	—	—	—	—	—	—	—	—	—	1
42	—	—	—	1	—	—	—	—	—	—
43	—	1	—	1	—	—	—	—	—	—
44	—	1	—	—	—	—	—	—	—	1
45	—	—	—	—	—	—	—	—	—	—
46	—	—	—	—	—	—	—	—	—	—
47	—	—	—	—	—	—	—	—	—	—
48	—	—	—	—	—	—	—	—	—	1
49	—	—	—	—	—	—	—	—	—	—
	860	483	22	63	399	170	402	182	39	71
	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—

Western Baltic.

Table 14.

Als — Ærø — Kiel.

♂

Year II	III	IV	V	VI	VII	VIII	IX	X	XI
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
1	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	2	2	—	—	—	—	—	—	—
—	1	—	2	1	—	—	—	—	—
—	1	3	7	2	1	—	—	—	—
—	2	4	16	13	6	2	—	—	—
—	2	7	14	29	33	5	3	2	—
—	—	7	12	15	15	10	1	—	—
—	—	9	14	28	20	3	6	—	—
—	2	7	18	21	15	17	6	2	1
—	—	4	5	9	9	7	3	6	3
—	1	2	7	5	5	6	3	4	—
—	—	—	1	7	5	6	4	1	—
—	—	—	1	1	4	2	1	—	—
—	—	1	—	1	1	—	—	—	—
—	—	—	—	—	—	1	2	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—

Plaice from the Baltic.

res are from my own investigations, 31. Aug. — 11. Septbr. 1920.

True Baltic

Table 15.

S. of Bagenkop.

Liste 16.

East of Falster (Møen).

	♀																			♂													♀																
	X	XI	XII	XIII	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
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